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Effect of severity, time to recompression with oxygen, and re-treatment on outcome in forty-nine cases of spinal cord decompression sickness

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Ball R. Effect of severity, time to recompression with oxygen, and re-treatment on outcome in forty-nine cases of spinal cord decompression sickness. Undersea & Hyperbaric Med 1993; 20(2):133–145.—For systematic study of the effects of clinical severity, time to recompression with oxygen, and re-treatment on outcome from spinal cord DCS, case records from the recompression chamber at the U.S. Naval Station Subic Bay were reviewed. Forty-nine cases of spinal cord DCS were classified using a numerical severity index and time to recompression with oxygen. Cases were divided by initial severity into mild, moderate, and severe groups and by time to recompression with oxygen into less than 12-h, 12–24-h, and greater than 24-h groups. Re-treatment effect was analyzed by severity after the first treatment and by the depth of the re-treatment table used. Severity after all treatment is strongly correlated with initial severity ($r = 0.88$) and moderately correlated with time to recompression with oxygen ($r = 0.58$). Response to treatment is significantly different among initial severity groups ($P < 0.001$). Delay to treatment worsens outcome for severely injured divers ($P = 0.008$). Residual severity after all treatments is highly correlated with severity after the first treatment ($r = 0.97$). There is no difference in re-treatment outcome by groups defined by severity after the first treatment or by 60- or 45-ft re-treatment tables.

dysbarism, central nervous system, model, hyperbaric oxygen therapy

The effect of clinical severity and time to recompression with oxygen on outcome from spinal cord DCS is not well defined in the diving medicine literature. Most case series have small numbers of divers with spinal cord symptoms and do not report data on severity and time to recompression with oxygen. In a series of 44 sport divers suffering from neurologic DCS, Dick and Massey (1) reported on the effect of severity but did not include time to recompression with oxygen; they found that 24 of 24 (100%) mildly injured divers obtained complete relief whereas only 1 of 6 (17%) severely injured divers did (1). Kizer (2) reported on the effects of delays in treatment but did not include a measure of severity; he found that 11 of 13 (84%) divers with arterial gas embolism (AGE) or neurologic DCS treated within 12 h obtained complete relief compared with 7 of 13 (54%) treated from 12 to 24 h after injury. Furthermore, neither of these studies used quantitative models that could be used prognostically. This paper uses retrospectively collected data from a series of cases with wide-ranging severity and time to recompression with oxygen to systematically study the effect of severity, time to treatment, and re-treatment on outcome from spinal cord DCS.

The recompression chamber at the U.S. Naval Station Subic Bay has served as a referral center for serious diving medical problems in the Philippines, including spinal cord DCS. Military divers, recreational scuba divers, and local commercial ("hose") divers have been treated for neurologic symptoms ranging from paresthesia to quadriplegia. Many divers experienced long delays before treatment and required multiple re-treatments. All available chamber records were reviewed to answer two questions: a) Can improvement from treatment be predicted knowing the initial severity and the time to recompression with oxygen; and b) can improvement of residual symptoms from re-treatments be predicted knowing residual severity?

METHODS

Chamber records at the Naval Station Subic Bay Ship Repair Facility from January 1985 to July 1990 were available at the time the review was conducted. Cases were classified as spinal cord DCS if symptoms included sensory or motor loss in the limbs that progressed from distal to proximal or implicated a particular spinal cord region (1) or if symptoms included patchy disturbances of sensation or paresthesia. Cases that involved pain-only DCS or primarily cerebral DCS were discarded. Time to symptoms was not included as a criterion for classification of spinal cord DCS because many divers who clinically seem to be suffering from this type of DCS have symptoms at depth or immediately upon surfacing (3). Diver demographic data, dive profiles, time to symptoms, initial treatment, initial hyperbaric therapy, time to initial hyperbaric therapy from onset of symptoms, ancillary therapy, number and type of repeat hyperbaric treatments, and complicating medical factors were culled from the records.

Clinically, the degree of severity of an injury is a continuum from wellness to severe dysfunction. Selecting a severity index that adequately represents this continuum, without being unduly cumbersome, is difficult. Scales for scoring severity of spinal cord injury ranging from discrete categories to detailed quantitative descriptions have been developed (4). Categorical scales limit the statistical techniques that can be applied to the data, whereas extremely detailed scales are difficult to implement, especially in a retrospective review where all the required data may not be available. A numerical severity index (Table 1) was selected from the literature (1) that had been used previously to study neurologic injury from DCS and was moderately easy to implement but had sufficient gradations to justify the use of statistical techniques for continuous data. The index was calculated at three time points based on the symptoms and signs reported: a) upon presentation to the recompression chamber (SEV1); b) after completion of the first hyperbaric treatment (SEV2); and c) after completion of all hyperbaric treatments (SEVALL). Each diver was assigned to one of three clinical severity groups: mild (1–3), moderate (4–6), or severe (7–10), first

Table 1: Spinal Cord Decompression Sickness Severity Index

Sensory symptoms		
Grade		
1	paresthesias	single limb or area
2	paresthesias	multiple regions
3	numbness	single limb or area
4	numbness	two limbs or areas
5	numbness	three or more limbs or areas
Motor symptoms		
Grade		
1	weakness	single limb or muscle group
2	weakness	multiple limbs or muscle groups
3	paralysis	single limb or muscle group
4	paralysis	two limbs
5	paralysis	three or more limbs
Total score = sensory grade + motor grade (maximum of 10)		
Severity groups		
Mild = 1–3		
Moderate = 4–6		
Severe = 7–10		

based on the initial severity score (SEV1) and then based on the residual severity score (SEV2). Percent improvement after all HBO treatments (IMPALL) was calculated as:

$$\mathrm{IMPALL} = [(\mathrm{SEV1} - \mathrm{SEVALL})/\mathrm{SEV1}] \cdot 100$$

Percent improvement of residual symptoms due to re-treatment (IMPRET) was calculated as:

$$\mathrm{IMPRET} = [(\mathrm{SEV2} - \mathrm{SEVALL})/\mathrm{SEV2}] \cdot 100$$

Each diver was assigned to one of three groups based on time to recompression with oxygen: early (0–12 h), delayed (12–24 h), and late (>24 h). Re-treatment methods were classified into two groups by depth of re-treatment. The 60-ft group included U.S. Navy treatment tables 5 and 6, whereas the 45-ft group included only a 45-ft table with three 30-min oxygen breathing periods with 5-min air breaks (HBO 45).

Statistical analysis

Two analyses were conducted to answer the question: Can improvement from all treatment be predicted knowing initial severity and time to recompression with oxygen?

First, several regression models were constructed to determine if severity after all treatments was linearly related to initial severity and time to recompression with oxygen. Linear models were selected as a first approximation to an unknown and probably complex underlying function because there was not sufficient information available in the literature to develop a detailed model of the effect of severity and time to recompression with oxygen on outcome a priori. Model I, SEVALL = $B_0 \cdot$ SEV1, was used to determine the predictive value of initial severity alone. Model II, SEVALL = $B_0 \cdot$ TIMEHBO, was used to determine the predictive value of time to recompression with oxygen alone. The combined model III, SEVALL = $B_0 \cdot$ SEV1 + $B_1 \cdot$ TIMEHBO, was constructed to determine if knowledge of both factors would improve the ability to predict SEVALL. Since severity after all treatment is assumed to be 0 if initial severity or time to recompression with oxygen were 0, no constant term is included in the models. The possible confounding of SEV1 and TIMEHBO was evaluated using correlation and model IV, SEV1 = B_0 + $B_1 \cdot$ TIMEHBO (5). B_0 and B_1 are the parameters in the models that are to be estimated. B_0 is the slope of the line relating SEVALL to SEV1 in model I and SEVALL to TIMEHBO in model II. In model III, B_0 and B_1 determine the slope of the plane that relates SEVALL to both SEV1 and TIMEHBO. In model IV, B_0 is the y axis intercept and B_1 is the slope of the line relating SEV1 to TIMEHBO.

Second, to test the hypothesis that response to treatment, as measured by percent overall improvement, differs among initial severity groups and to account for differences by time to recompression with oxygen groups, a two-way analysis of variance (ANOVA) of overall improvement by severity group and time to recompression with oxygen group was conducted. If the hypothesis that all cell means are equal was rejected, a pairwise comparison of cell means within a factor was carried out using a Fisher Least Significant Difference test to determine which cell means were different. If the hypothesis that the marginal means of a factor were all equal was rejected, a pairwise comparison of the marginal means was carried out (6).

In an analogous manner, two analyses were conducted to answer the second question: Can improvement of residual symptoms from retreatment be predicted knowing residual severity?

First, to test the hypothesis that a predictive model of the effect of residual severity on severity after all treatment could be found using individual case data, the regression model V, SEVALL = $B_0 \cdot$ SEV2, was constructed. Residual severity (SEV2) alone was used in the model because the effect of initial severity, time to recompression with oxygen, and the initial hyperbaric treatment are all accounted for in SEV2. B_0 is the slope of the line relating SEVALL to SEV2 and is to be estimated from the data.

Second, to test the hypothesis that response to re-treatment, as measured by percent residual improvement, differs among residual severity groups and to control for re-treatment methods, a two-way ANOVA of residual improvement by residual severity group and re-treatment method was conducted. In all cases, a test was considered significant if $P \leq 0.05$. All analyses were conducted using SYSTAT version 5.03 running under DOS (7).

RESULTS

Description of cases

One hundred and thirty-two cases of DCS or AGE were treated from January 1985 through July 1990. Eighteen cases (14%) involved pain only, 2 cases involved altitude exposure, and 112 cases (85%) involved neurologic injury from diving. Only 65 cases from the latter group had records that were complete. From these, 16 cases of AGE or DCS with primarily cerebral manifestations were excluded and 49 cases were selected for review.

The 49 cases included 37 (75.5%) "hose" divers, 11 (22.5%) recreational scuba divers, and 1 (2.0%) military diver. There were 46 (93.9%) men and 3 (6.1%) women. The mean age ($\pm$ SD) was 27.1 $\pm$ 6.2 yr (n = 48). Twenty-two divers (47.8%) developed symptoms within 10 min of surfacing.

The majority of initial treatments followed standard U.S. Navy guidelines (8) and included treatment with extended treatment table 6 in 28 cases (57.1%) and standard treatment table 6 in 18 cases (36.8%). Three cases with several days delay before treatment were treated with other tables. U.S. Navy treatment table 5 was used in one case and the HBO 45 table in 2 cases. Ancillary care consisted of oral or i.v. fluids, bladder catheterization, and antibiotics as prescribed by the on-scene diving medical officer. Twenty-two cases (44.9%) received i.v. steroids and 27 (55.1%) did not.

Thirty-three cases (67.3%) required re-treatment. Three patients were treated for recurrence of symptoms after initial complete relief and required one additional treatment each to gain permanent complete relief. These cases are not included in the analysis of residual symptom response to re-treatment. Thirty cases required re-treatment for residual symptoms after the first HBO. Re-treatments were conducted with table 6 or extended table 6 (10 cases), a combination of table 6 and table 5 (2 cases), table 5 alone (1 case), or the HBO 45 table alone (15 cases) until no improvement was noted. In two cases the type of re-treatment was not noted in the record and these cases are excluded from the analysis. One re-treatment was conducted every 24 h.

While one of the goals of this study was to construct a predictive model, much information can be gained by directly studying trends in the data. Inspection of the raw data illustrates a threshold at severity score 5. Almost all cases (95%) with initial severity score of 5 or less obtained complete relief, regardless of delay to treatment, whereas only 6% of cases with an initial severity score of 6 or greater obtained complete relief. Furthermore, the latter group of cases demonstrate a clear dependence on time to recompression with oxygen. Figure 1 shows that for cases with an initial severity score of 6 or greater, change in severity is maximized if treatment is initiated within 12 h of injury. However, even early treatment does not guarantee success; only two of four cases treated within 4 h obtained complete or near-complete relief.

Statistical analysis

The correlation analysis on the individual case data using model IV showed that time to recompression with oxygen does not provide reliable prediction of initial severity (r = 0.122). Analysis of models I and II demonstrates that severity after all treatments is linearly related to initial severity (r = 0.88) and severity after all treatments is linearly related to time to recompression with oxygen (r = 0.58). However, combining time to recompression with oxygen with initial severity in model III adds little over initial severity alone (r = 0.89). Figures 2 and 3 contain individual data plots and regression lines with 95% confidence intervals, and Table 2 contains

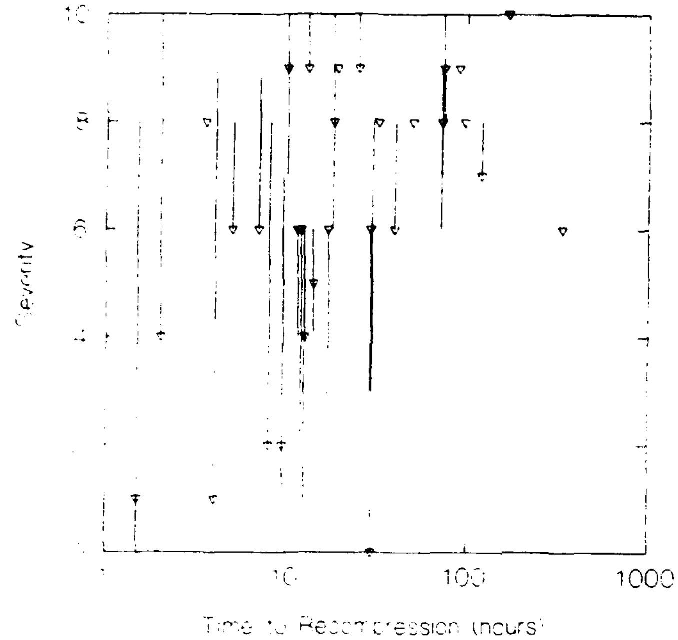

FIG. 1—Change in severity by initial severity and time to recompression with oxygen for initial severity ≥6. Each *vertical line* represents one case; *top of the line* is initial severity; *triangle* is severity after the first treatment; *bottom of the line* is severity after all treatments.

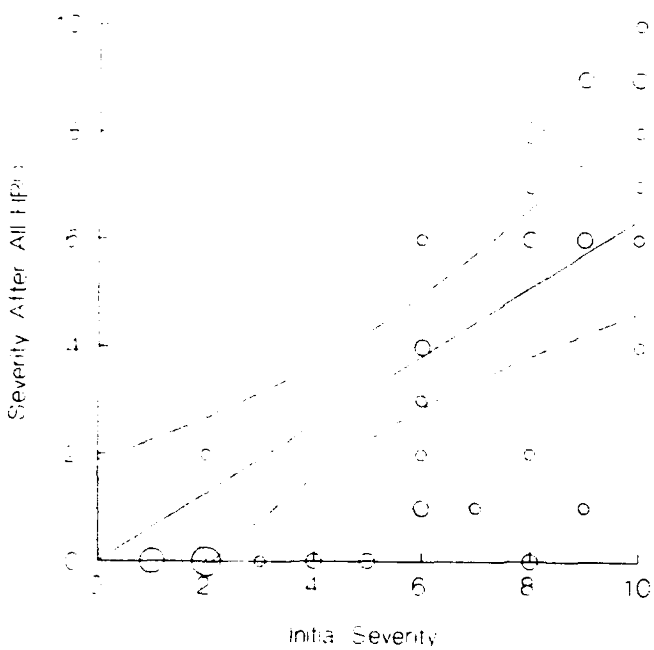

FIG. 2—Effect of initial severity on severity after all HBO therapy. *Open circles* are proportional to number of cases; *solid line* represents fitted regression line; *dashed lines* represent 95% confidence interval.

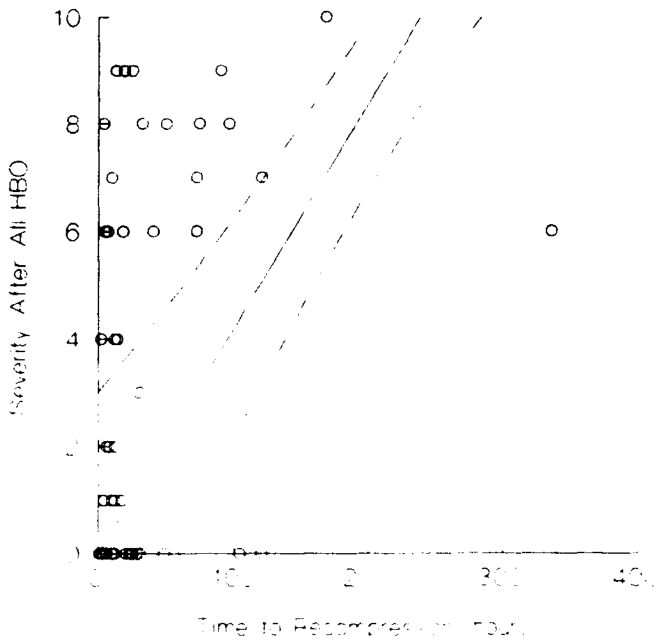

FIG. 3—Effect of time to recompression with oxygen on severity after all HBO therapy. *Open circles* are proportional to number of cases; *solid line* represents fitted regression line; *dashed lines* represent 95% confidence interval.

the parameter estimates for the associated regression lines. In Fig. 2, 53% of the cases fall outside the 95% confidence interval of the regression line predicting overall severity from initial severity, and 47% of the cases fall outside the 95% confidence interval of the regression line predicting overall severity from time to recompression with oxygen in Fig. 3.

The analysis of percent improvement by initial severity group and time to recompression with oxygen group rejected the hypothesis that all cell means are equal ($P < 0.001$). There was no significant interaction effect between the initial severity groups and time to recompression with oxygen groups ($P = 0.160$). In addition, percent improvement among the initial severity groups is different ($P < 0.001$). Furthermore, all pairwise comparisons among severity group marginal means were statistically significant. There was not a significant difference by time to recompression with the oxygen group ($P = 0.229$). However, in the severe group the early subgroup cell mean was different from the late subgroup cell mean ($P = 0.008$). The mean and standard error of the percent improvement of individual cases within a severity–time to recompression with the oxygen group are presented in Table 3.

The regression analysis on the individual data using model V of overall severity against residual severity shows that the two variables are highly correlated ($r = 0.969$). The slope of the line is 0.862 with a standard error of 0.043. This is significantly different from a slope of 1 ($P = 0.003$), which would imply that there is a statistically significant linear effect of re-treatment. Figure 4 contains the data plot and associated regression line with the 95% confidence interval.

The analysis of residual improvement by residual severity group and re-treatment type showed no significant linear effect of either variable and no interaction effect. The overall mean for improvement of residual symptoms is 19 ± 6%.

Table 2: Regression Models for Analyzing Severity and Time to Recompression with Oxygen Data

Model I Effect of initial severity on severity after all treatments

SEVALL = $B_0 \cdot$ SEV1

B_0	SE	P	r
0.64	0.05	0.001	0.88

Model II Effect of time to recompression with oxygen on severity after all treatments

SEVALL = $B_0 \cdot$ TIMEHBO

B_0	SE	P	r
0.04	0.008	0.001	0.58

Model III Effect of initial severity and time to recompression with oxygen on severity after all treatments

SEVALL = $B_0 \cdot$ SEV1 + $B_1 \cdot$ TIMEHBO

B_0	SE	P	B_1	SE	P	r
0.58	0.06	0.001	0.011	0.006	0.06	0.89

Model IV Test for confounding of initial severity by time to recompression with oxygen

SEV1 = B_0 + $B_1 \cdot$ TIMEHBO

B_0	SE	P	B_1	SE	P	r
5.746	0.542	0.001	0.007	0.008	0.404	0.122

Model V Effect of severity after first treatment on severity after all treatments

SEVALL = $B_0 \cdot$ SEV2

B_0	SE	P	r
0.862	0.043	0.001	0.969

Key: SEVALL = severity after all treatments, SEV1 = initial severity; SEV2 = severity after initial recompression with oxygen; TIMEHBO = time to initial recompression with oxygen; B_0 and B_1 = parameters to be estimated from regression; SE = standard error of the parameter estimate; P = P value for the test of the hypothesis that the parameter estimate is significantly different from 0; r = multiple correlation coefficient.

Table 3: Improvement after all HBO Treatments by Initial Severity and Time to Recompression with Oxygen

	Percent Improvement ± SE, Number of Cases							
	Early		Delayed		Late		Mean	
Mild	83 ± 13	6	100 ± 18[a]	3	100 ± 14[b]	5	94 ± 9[c]	14
Moderate	81 ± 13	6	58 ± 22	2	50 ± 18	3	63 ± 10[c]	11
Severe	55 ± 10[d]	9	17 ± 18[a]	3	18 ± 9[b,d]	12	30 ± 7[c]	24
Mean	73 ± 7	21	58 ± 11	8	56 ± 8	20	57 ± 5	49

Key: Mild = severity score 1–3; moderate = severity score 4–6; severe = severity score 7–10. Early = <12 h to recompression with oxygen; delayed = 12–24 h to recompression with oxygen; late = >24 h to recompression with oxygen.

[a]Delayed-mild and delayed-severe subgroups are significantly different (P = 0.043); [b]late-mild and late–severe subgroups are significantly different (P < 0.001); [c]initial severity score groups are significantly different (P < 0.001); [d]severe-early and severe-late subgroups are significantly different (P = 0.008).

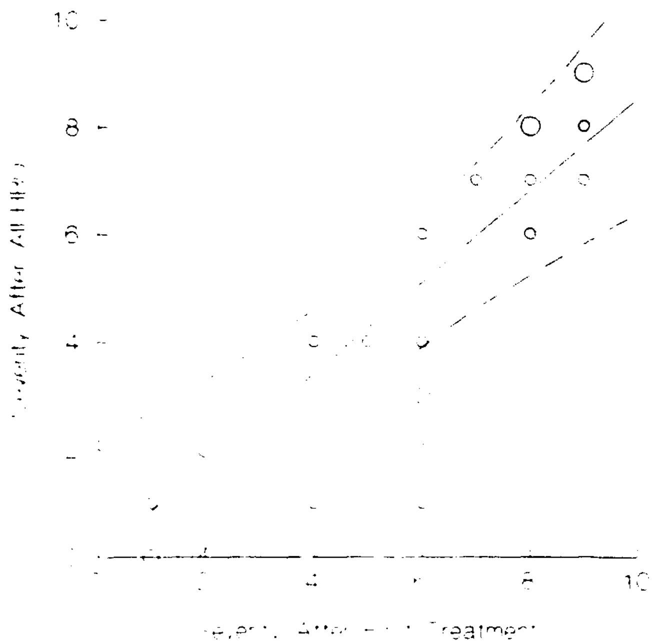

FIG. 4—Effect of severity after the first treatment on severity after all HBO therapy. *Open circles* are proportional to number of cases; *solid lines* represent fitted regression line; *dashed lines* represent 95% confidence interval.

DISCUSSION

The trends observed in the data suggest that almost all divers with severity less than or equal to 5 obtain complete relief regardless of time to recompression with oxygen. More severely injured divers are dependent on early treatment to maximize improvement. Treatment greater than 12 h after onset of injury for this group will not result in substantial improvement for most injured divers and, generally, re-treatment contributes little to overall improvement.

However, despite the minimal benefit re-treatment provides on average, a poor response to the first treatment does not imply with certainty that re-treatment will not be of benefit. A substantial number of such cases, although a minority, will obtain improvement from re-treatment. This is especially true for divers with moderate initial severity. These results support the current practice of beginning re-treatments on all divers with residual symptoms after the first treatment because response to the initial treatment does not accurately predict response to re-treatment.

Although the trends observed in the data are informative, the statistical analyses formally test the hypothesis that a quantitative model of the effect of severity and time to recompression with oxygen can be developed. These analyses demonstrate that, for an individual diver, a precise prediction of improvement from treatment cannot be made from the original severity at presentation and time to recompression with oxygen using linear regression models and the severity scale of Dick and Massey (1). Selection of a model with a threshold may improve the fit, but the variability in response of the cases with severity of 6 or greater may preclude accurate prediction regardless of the model selected.

Although residual severity is strongly linearly associated with severity after all re-treatments, the individual scores can be used to predict response to re-treatment only for divers with mild or severe residual injury. The improvement from re-treatment of divers with residual severity in the moderate range is underpredicted by the linear regression model. Despite this inability to accurately predict individual responses to treatment, the group analyses provide information that can be used for quantitative prognostication.

The group analyses formally confirm the observation that the severity group is a good predictor of improvement from treatment and the importance of treatment within 12 h for severely injured divers. The lack of a statistically significant effect of time to recompression with oxygen in the moderately injured group may be because the small number of cases in some cells decreases the power of the analysis to detect small differences. Knowledge of the time to treatment might be useful for the moderate severity group as well, but a larger study would be needed to answer this question definitively. Furthermore, no significant difference by residual severity group or re-treatment table depth was detected. This implies that the overall mean should be used to predict the improvement of residual symptoms from re-treatment. As described above, the small sample size may not allow detection of small differences. Nevertheless, this analysis formally confirms the observation that most improvement occurs during the first treatment and that re-treatment contributes relatively little to overall improvement.

Several caveats must be mentioned before attempting to generalize these results. The large proportion of missing records (49%) increases the chance that the conclusions drawn about the sample population will be biased. This would be the case if the study variables in the missing records are different from those in the study population. Since symptoms, signs, and time to recompression information were recorded together in the medical records, it was not possible to blind the severity-scoring process. Furthermore, all scoring and data gathering were done by the same person, which could bias the results.

Extrapolation of these results to the general diving population is hampered by the makeup of the sample population. The majority of the sample consists of hose divers who use homemade surface-supplied diving equipment to make repetitive, long, and deep dives, often without regard for decompression schedules. The extreme decompression stress they undergo may result in a different mechanism of injury than that experienced by the typical recreational or professional diver. Consequently, they may not be directly comparable to the divers who develop DCS while diving within the tables or with only small amounts of omitted decompression. However, initial severity and time to recompression with oxygen were selected as the study variables to provide objective factors that could be compared across groups independent of diving methods. In this way, speculation about mechanisms of disease could be minimized. The intent of this study was to determine if severity and time to treatment alone, without consideration of other factors, can be used prognostically.

Comparison of these results with those in the literature confirms the observations on the importance of initial severity on outcome. This study is unique in analyzing the combined influence of severity and time to recompression with oxygen on outcome, hence direct comparison with other studies is difficult. Furthermore, only limited information on re-treatments is presented in other studies, making direct comparison impossible. The remaining discussion relates the current study's results with those highlighted in Table 4.

When the effect of severity is not noted, complete relief rates range from 27.6 to 84% (2, 9–12). The importance of severity is demonstrated with stratification by the severity group. Complete relief rates up to 100% in mildly neurologically injured divers have been reported (1), but for severely injured, paraplegic, or quadriplegic divers the range is from 0 to 17% (1, 13, 14). The current study, using the same severity scale as Dick and Massey (1), shows comparable proportions of divers suffering mild and severe injury who obtained complete relief. This is despite the differences in ethnicity, diving methods, and average severity in the populations under study. The difference in the moderate group between Dick and Massey and this study may be due to a preponderance of category 6 in that group with 12 h or more to recompression and the subsequent poor response to treatment. The current study demonstrates that the prognostic power of this severity scale is not improved by classifications finer than mild, moderate, and severe. Indeed, the clear threshold at category 5 suggests that only 2 categories may be needed for prognostication. This could only be decided definitively by obtaining a case series with a large number of cases in each severity–time to recompression therapy category.

Table 4: Neurologic Decompression Sickness Treatment Success Rate

		Complete Relief		
Source	Severity	No. Cases	Percent	Comments
Current study	mild	13/14	93	
	moderate	4/11	36	
	severe	2/24	8	
Total		19/49	39	
Dick and Massey (1)	mild	24/24	100	neurologic DCS
	moderate	10/14	71	
	severe	1/6	17	
Total		35/44	80	
Kizer (2)		11/13	84	12–24 h
		7/13	54	>24 h
				DCS and AGE
How and Long (9)	78% with limb paralysis	22/51	43	97% after 24 h
Hart et al. (10)		15/20	75	spinal cord DCS
Dembert (11)		8/29	28	neurologic DCS
Cross (12)		28/42	67	DCS and AGE
Girard (13)	paraplegia	0/13	0	spinal cord DCS
Hayashi et al. (14)	T9-T12	1/8	13	spinal cord DCS
	T5-T8	1/6	17	
	C1-T6	0/12	0	
Total		2/26	8	

Kizer (2) reported on delays in treatment greater than 12 h in patients with DCS and AGE without subclassification by severity. He found that 84% treated from 12 to 24 h after injury obtained complete relief, whereas only 54% did so if treated after 24 h. These percentages compare with 38 and 35% for groups treated greater than 12 and 24 h after onset of symptoms, respectively, in this study. In addition, the current study found only a moderate association between time to recompression with oxygen and response to treatment. This difference may be explained by a different severity mix in the populations under study. In the current study, mildly injured divers did not seem to be dependent on time to recompression with oxygen, because almost all such divers obtained complete relief. However, in the moderately and severely injured diver groups the trend was toward fewer divers obtaining complete relief with greater delays in time to recompression with oxygen. A higher proportion of mildly injured divers in Kizer's study (2), distributed unequally among time to treatment groups, would increase the complete relief rate disproportionately. How and Long (9) noted 43% complete relief in their injured diver population even though 97% were treated more than 24 h after onset of symptoms. This value is comparable to the 35% complete relief rate for the late-treated group in this study, probably because their study population consisted of divers with similar severity.

There is little quantitative information on the value of re-treatments. Kizer (2) reported that four patients required between two and eight re-treatments to obtain complete relief. Dembert (11) noted that treatments were continued until there was no improvement, but did not report on the number of re-treatments required. Hart et al. (10) noted that 16 patients with DCS or AGE required an average of 4.8 re-treatments. How and Long (9) noted that some patients had up to seven re-treatments. However, none of these studies reported on the proportion of improvement contributed by re-treatments. Several reports on patients that either did not receive HBO or received HBO initially followed by physical therapy or no treatment noted that many patients showed gradual recovery, especially if the insult resulted in only mild symptoms (1, 9, 13).

Re-treatment regimens are nonstandard and range from daily treatment table 6 (13) to 2.5 atm abs for 90 min 3 times a day for the first 24 h, followed by 2.0 atm abs for 90 min twice daily thereafter (10). Furthermore, there is no well-studied criterion for terminating re-treatments other than obtaining complete relief. A common practice is to treat until a plateau in improvement is reached. The current study suggests that re-treatment with short courses of once daily HBO provides only a small portion of overall improvement. This report suggests that re-treatment at 60 or 45 ft does not result in significant differences, but can offer no recommendations regarding length or frequency of HBO exposures. Additionally, this study does not help to define an endpoint for re-treatments because re-treatments typically were terminated after completing two HBO exposures beyond a plateau in improvement. No data are available on what effect long term HBO might have had.

Despite the high overall success rates reported using the current methods for treating DCS (15), this study demonstrates that the effectiveness of treatment for severe spinal cord DCS is poor and that re-treatment of residual symptoms with short courses of HBO in such cases offers little benefit. Future studies of spinal cord DCS should include a severity subclassification scale, as well as an analysis by time to treatment to provide a standard for comparing outcomes. Although the severity scale used in this study provides a method of classification that is useful for prognostication, it may not be the best scale for all purposes. Selection of the optimal severity scale to serve as a standard part of a classification system of DCS should be a goal of the diving medicine community.

The opinions and assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Department of the Navy or the naval service at large.

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